



PATENT
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Nie et al.

Application No. 09/405,653

Filed: September 24, 1999

Group Art Unit: 1765

Examiner: Unassigned

For: WATER-SOLUBLE LUMINESCENT
QUANTUM DOTS AND BIOMOLECULAR
CONJUGATES THEREOF AND RELATED
COMPOSITIONS AND METHOD OF USE

PENDING CLAIMS AS OF FEBRUARY 19, 2001

1. A water-soluble luminescent semiconductor quantum dot, which comprises a core, a cap and a hydrophilic attachment group, wherein the water-soluble luminescent semiconductor quantum dot remains in solution for at least about one day.
2. The water-soluble luminescent semiconductor quantum dot of claim 1, wherein the hydrophilic attachment group is attached to said quantum dot via a sulfur atom.
3. The water-soluble luminescent semiconductor quantum dot of claim 2, wherein said hydrophilic attachment group is an organic group comprising a sulfur atom and at least one hydrophilic substituent.
4. The water-soluble luminescent semiconductor quantum dot of claim 3, wherein said hydrophilic substituent is selected from the group consisting of a carboxylic acid or salt thereof, a sulfonic acid or salt thereof, a sulfamic acid or salt thereof, an amino substituent, a quaternary ammonium salt, and a hydroxy.
5. The water-soluble luminescent semiconductor quantum dot of claim 3, wherein said organic group is a C₁-C₆ alkyl group or an aryl group.
6. The water-soluble luminescent semiconductor quantum dot of claim 3, wherein said organic group is a C₁-C₆ alkyl group.

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7. The water-soluble luminescent semiconductor quantum dot of claim 3, wherein said hydrophilic attachment group is a thiol carboxylic acid or thiol alcohol.

8. The water-soluble luminescent semiconductor quantum dot of claim 7, wherein said hydrophilic attachment group is mercaptoacetic acid.

9. The water-soluble luminescent semiconductor quantum dot of claim 1, wherein the core of the quantum dot is selected from the group consisting of IIB-VIB semiconductors, IIIB-VB semiconductors, and IVB-IVB semiconductors and the size of the core is from about 1 nm to about 10 nm.

10. The water-soluble luminescent semiconductor quantum dot of claim 9, wherein the core of the quantum dot is selected from the group consisting of IIB-VIB semiconductors and the size of the core is from about 2 nm to about 5 nm.

11. The water-soluble luminescent semiconductor quantum dot of claim 10, wherein the core of the quantum dot is CdS or CdSe.

12. The water-soluble luminescent semiconductor quantum dot of claim 11, wherein the core of the quantum dot is CdSe.

13. The water-soluble luminescent semiconductor quantum dot of claim 12, wherein the size of the core is about 4.2 nm.

14. The water-soluble luminescent semiconductor quantum dot of claim 1, wherein the cap is selected from the group consisting of IIB-VIB semiconductors of high band gap.

15. The water-soluble luminescent semiconductor quantum dot of claim 14, wherein the cap is ZnS.

16. The water-soluble luminescent semiconductor quantum dot of claim 11, wherein the cap is ZnS.

17. The water-soluble luminescent semiconductor quantum dot of claim 14, wherein the cap is CdS.

18. The water-soluble luminescent quantum dot of claim 12, wherein the cap is CdS.

19. A water-soluble luminescent semiconductor quantum dot, which comprises a CdSe core, a ZnS cap and a mercaptoacetic acid attachment group.

20. The water-soluble luminescent semiconductor quantum dot of claim 19, wherein the CdSe core is about 4.2 nm and the ZnS coating is about 1 nm.

21. A composition comprising the water-soluble luminescent semiconductor quantum dot of claim 1 and an aqueous carrier.

22. A composition comprising the water-soluble luminescent semiconductor quantum dot of claim 19 and an aqueous carrier.

23. A composition comprising the water-soluble luminescent semiconductor quantum dot of claim 20 and an aqueous carrier.

38. A method of obtaining a water-soluble luminescent semiconductor quantum dot, which method comprises:

- (a) reacting a luminescent semiconductor quantum dot in a nonpolar organic solvent with a first aqueous solution comprising an attachment group;
- (b) adding a second aqueous solution of about neutral pH and mixing; and
- (c) extracting an aqueous layer, thereby obtaining a water-soluble luminescent semiconductor quantum dot.

39. The method of claim 38, wherein the nonpolar organic solvent is chloroform and the compound is mercaptoacetic acid.